(12) UK Patent Application (19) GB (11) 2 108 900 A

(21) Application No 8231427
(22) Date of filing 3 Nov 1982
(30) Priority data
(31) 320463
(32) 12 Nov 1981
(33) United States of America (US)
(43) Application published 25 May 1983
(51) INT CL³ B29C 1/14 B29D 1/00
(52) Domestic classification B5A 1R214E 1R314C2S 1R314C2X 1R400 1R432 20T9 B11 U1S 1246 1269 B5A
(56) Documents cited GB 1580962 GB 1453936 GB 1173762 GB 0788063 GB 0761641
(58) Field of search B5A
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(54) Fibre-reinforced sucker rod

(57) A sucker rod (10) is moulded from plastic material having reinforcing fibre strands (32) therein. A bundle of resin impregnated flexible reinforcing strands are placed in a split mould and the mould closed. The strands in the end threaded regions of the mould (22, 32) are held in position during moulding by mould plugs so that the threads are reinforced.

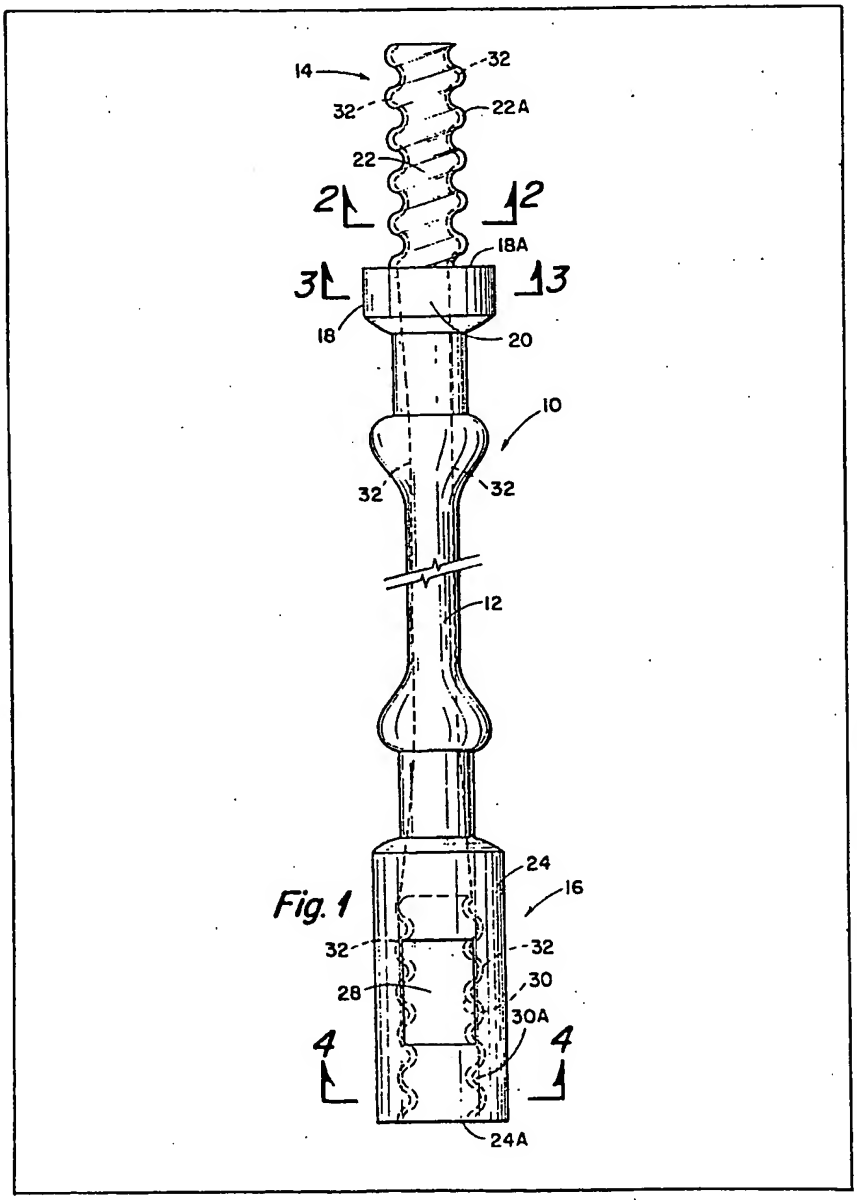

Fig. 1

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This print takes account of replacement documents later filed to enable the application to comply with the formal requirements of the Patents Rules 1978 or 1982.

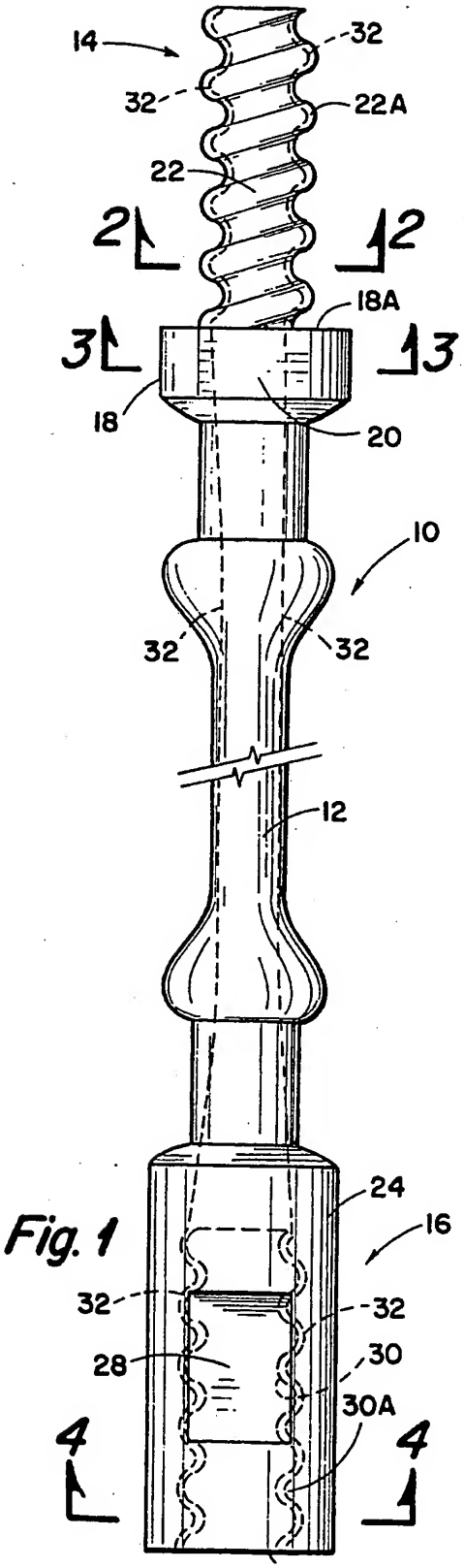

Fig. 1

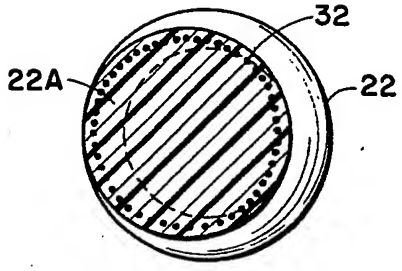

Fig. 2

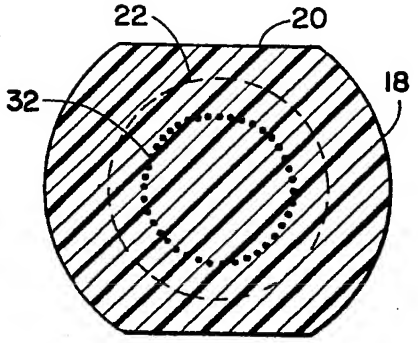

Fig. 3

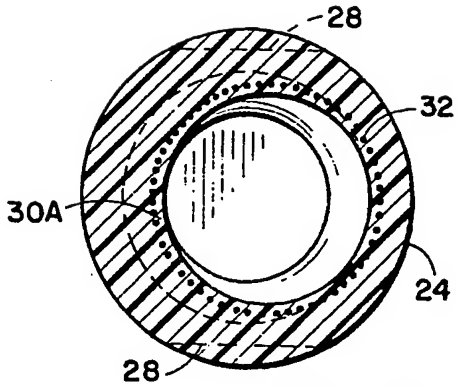

Fig. 4

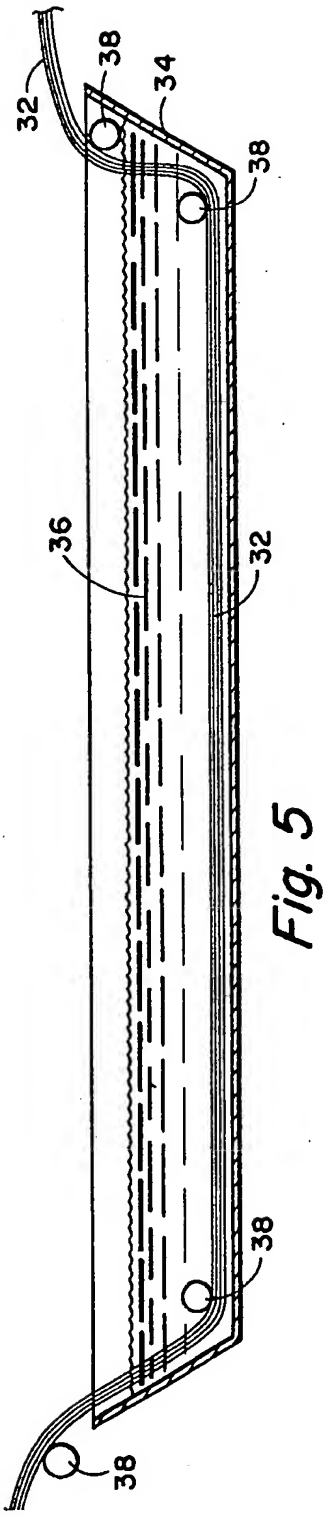

Fig. 5

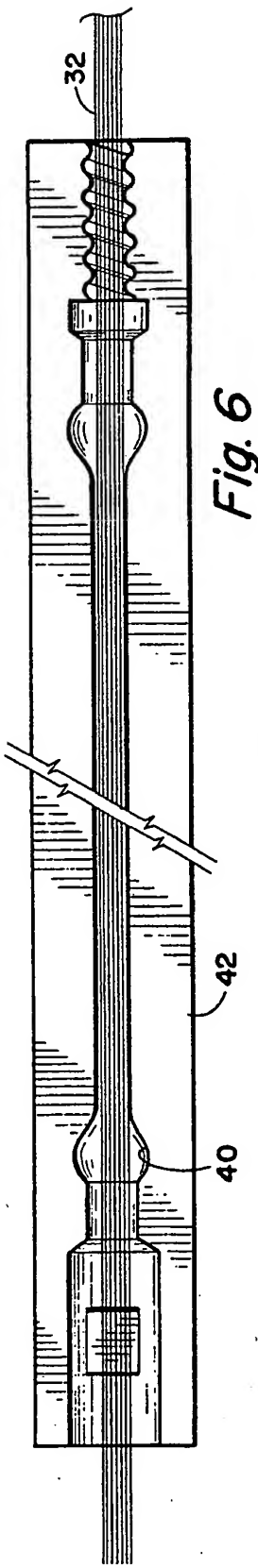

Fig. 6

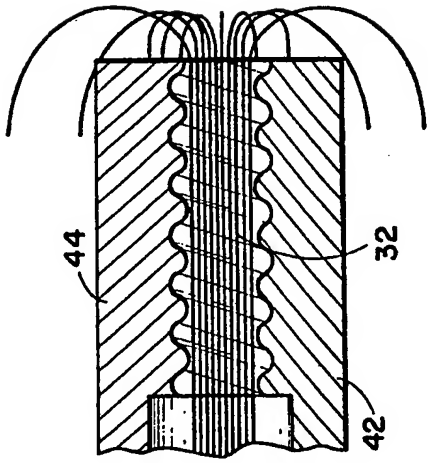

Fig. 7

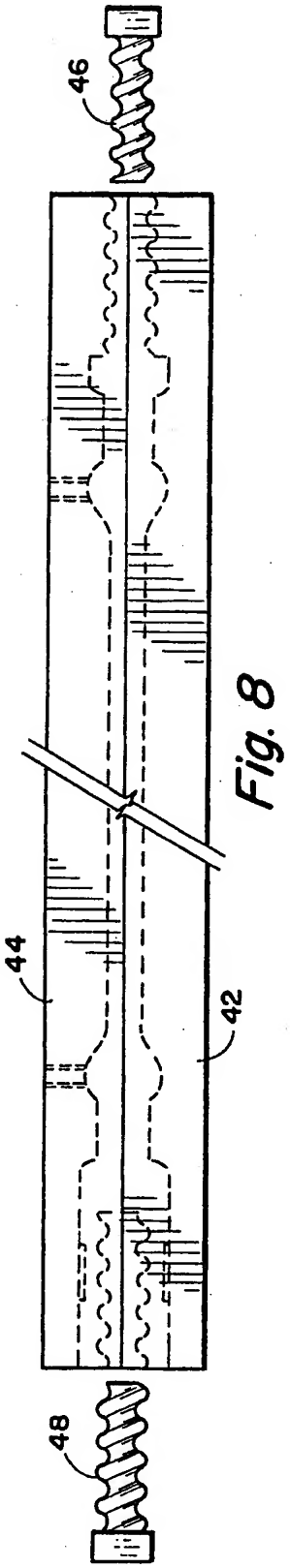

Fig. 8

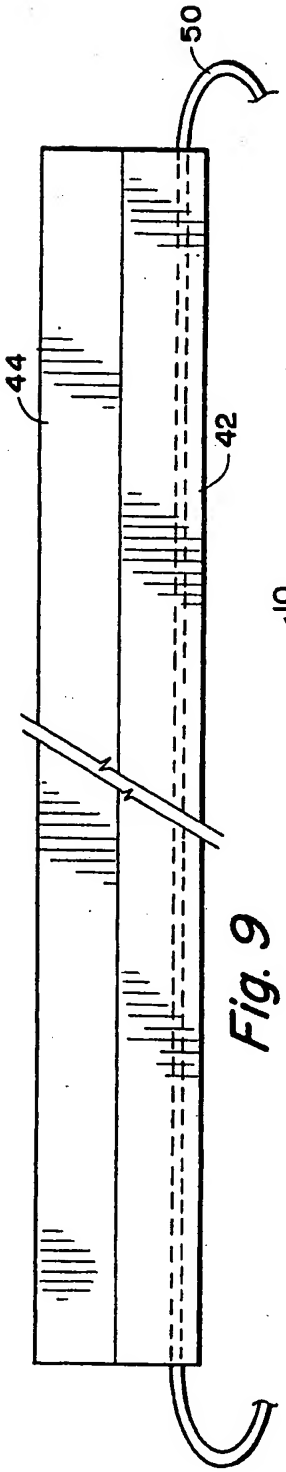

Fig. 9

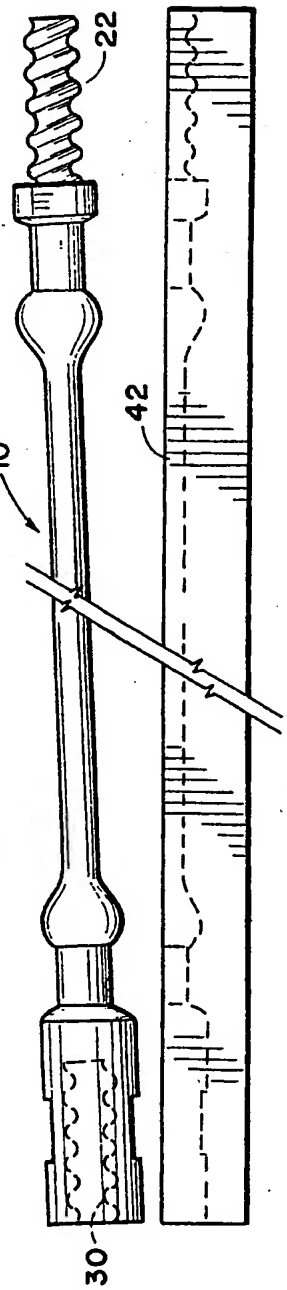

Fig. 10

SPECIFICATION

Fiber reinforced resin sucker rod and method of making same

This invention relates to an improved sucker rod made of plastic materials and more particularly to a fibre reinforced plastic sucker rod in which the threads at each end of the sucker rod are of increased strength, the fibers being continuous through the apex portion of the threads and to a method of manufacturing such improved sucker rod.

Fiber reinforced sucker rods have been manufactured for some time, but because of limitations in existing products, they have not been universally employed in the petroleum industry. Attempts to manufacture fiber reinforced sucker rods with integral internal and external threads with strength equal to the rod body have been unsuccessful. Furthermore, it is not practical to machine a thread into a resin fiberglass laminated sucker rod or other types of fiber reinforced sucker rods because machining cuts the reinforcing fibers and weakens the structures to such an extent that in use the threads break, thus being of no value as a coupler.

To overcome this problem, others have employed plastic and fiberglass sucker rods having metal couplings affixed to each end of the rod. This technique has not been universally successful due to the lack of uniformity and predictability and the higher manufacturing costs. Also the metal parts can only be attached to the surface fibers of the rod which bypasses the main strength of the fiber bundle in the rod. In addition, the high coefficient of friction characteristic of fiber reinforced plastic overcomes the problem of metal unthreading in service due to its low coefficient of friction. The metal fittings attached to the rod also cause increase in the weight of the rods and their susceptibility to corrosion.

An object of the present invention is to overcome these difficulties and to provide a uniform fiber reinforced plastic sucker rod that is equally strong in the threads as in the main body of the rod.

According to the present invention a method of manufacturing a fiber reinforced plastic sucker rod having a threaded portion at each end thereof using a split cavity mold which, when closed has a cavity defining the external configuration of the finished sucker rod, comprises positioning a plurality of pre-resin saturated flexible reinforcing fiber strands in one-half of the mold, maintaining the strands in proximity of the mold wall in the areas thereof of the threaded end portions while adding additional resin compound to the mold, closing the mold, curing the plastic material within the mold and separating the mold to remove the formed sucker rod.

Also according to the invention a plastic sucker rod comprises an elongated sucker rod formed of plastic material having a plurality of reinforcing fiber strands therein, the sucker rod having a threaded portion at each end thereof, the fiber strands in the threaded portions being continuous and generally in planes of the sucker rod longitudinal axis with all of the fiber strands extending within the thread's configuration and apex portions.

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which

Fig. 1 is an elevation of a plastic sucker rod showing the external configuration and the arrangement of the reinforcing fibers in dotted outline;

Figs. 2, 3 and 4 are cross-sectional views taken along the lines 2—2, 3—3, and 4—4 respectively of Fig. 1;

Fig. 5 is a diagrammatic view showing a vessel in cross-section and showing fiber strands being pulled through the vessel as a means of saturating the strands with liquid thermosetting resin;

Fig. 6 is a plan of the lower portion of a split cavity mold for forming the sucker rod, the mold having a cavity therein defining the external configuration of the finished sucker rod, and showing the saturated fiber strands positioned in the cavity of the mold lower portion;

Fig. 7 is an enlarged cross-sectional view of one end portion of a split cavity mold wherein the bottom and top halves of the mold are joined together and showing the arrangement of the fibers within the mold in the portion thereof wherein the male threads are to be formed;

Fig. 8 is a side elevation of the split cavity mold with the top and lower portions joined together and the mold cavity shown in dotted outline and showing the flaring tools which are employed for insertion into the ends of the mold for displacing the reinforcing fibers into the areas of the mold so that they will be retained within the apex portion of the male and female threads;

Fig. 9 is an external view of the mold showing the circulation of the heating fluid therein to cure the thermosetting resin within the mold;

Fig. 10 shows the lower portion of the mold, the top portion having been removed, and showing the completed sucker rod.

An improved plastic sucker rod of this invention is illustrated in Figs. 1 to 4. The sucker rod, indicated generally by the numeral 10, has an external configuration similar to sucker rods which have been manufactured in the past as employed in the petroleum industry. Typically, sucker rods are 25 feet in length, with a maximum outside diameter in the area of the couplings of $1\frac{1}{2}$ inches or less. The sucker rods are utilized to impart pumping motion from a pumping unit on the surface of the earth to a bottom hole pump. Thus the sucker rods reciprocate up and down within a tubing. In order to lift a fluid column from the bottom of a well to the earth's surface to cause the fluid to be pumped to the surface, sucker rods must withstand substantial tensile loads. The most commonly employed sucker rod in the industry today is made of steel or steel alloys. However, it is subject to corrosion; and in many well conditions, steel sucker rods have relatively

short lives. To combat this, manufacturers have produced alloy sucker rods which are less susceptible to corrosion, but alloy sucker rods are prohibitive in price. The present invention provides a sucker rod which is substantially immune to corrosion and which has other advantages over steel or other alloy sucker rods.

The rod 10 includes a long, cylindrical, straight body portion 12. At one end is a pin end or male end, generally indicated by the numeral 14, and at the other end is a box end or female end generally indicated by the numeral 16. In this manner of construction (which is typical of the construction of some types of steel sucker rods), the rods may be threaded together without the use of separate couplings. In the past steel sucker rods have been manufactured in this way; however, in recent years the most common steel sucker rods have a male thread at each end with a separate female coupling used to connect rods together. The advantages of the rod of the type illustrated in Fig. 1 is that no separate coupling devices are required.

The male end 14 generally includes an enlarged head portion 18 with a planar annular surface 18A which is perpendicular to the longitudinal axis of the rod. The head portion 18 includes wrench flats 20 as shown in Fig. 3 which provide means for engaging the end of the rod with a wrench so that it may be tightened to an adjacent rod.

Forwardly of the head portion 18 is a male portion 22 having threads on the exterior surface.

The female end 16 includes an elarged external diameter section 24. The female end includes the provision of opposed wrench flats 28 on the opposite side of the enlarged cylindrical portion 24.

Within the interior of the cylindrical portion 24 are internal threads 30 which are configured to receive the male threads of a next adjacent length of sucker rod. The end surface 24A is annular and in a plane perpendicular to the longitudinal axis of the sucker rod. When a male threaded end of the next adjacent sucker rod is threaded into the box end 16, the male annular surface 18A tightly abuts the female annular surface 24A to ensure that no "play" exists in the threaded joint formed in securing one rod to another.

The sucker rod described up to this point is not unlike metal sucker rods previously known. An important and distinctive feature, however, of the sucker rod of this invention is that it is formed of non-metallic material, that is, plastic material, but most importantly, is imbued with increased strength by the provision of longitudinal flexible reinforcing fiber strands 32 indicated by the dotted lines in Fig. 1 through 4. The fiber strands 32 are preferably of the full length of the sucker rod, and of utmost significance to the invention is the arrangement of the fiber strands 32 so that they extend adjacent the exterior peripheral surface of the male threads 22 and the female threads 30. Specifically, the fiber strands 32 extend within the apexes of the threads which form the male threaded portion 22 and the female threaded portion 30. In this manner, the fibers are locked together into a continuous configuration of threads having equal strength to the rod body. In the past, as previously indicated, attampts to manufacture plastic sucker rods have not been highly successful since the most common employed technique has been to attach metal threaded ends to a pulltruded fiber reinforced rod. Even when a large amount of reinforcing fibrous strands are utilised in formation of the sucker rod, the problem of connecting the rod with full tensile strength has remained unsolved until now.

As indicated in Figs. 2 and 4, the reinforcing fiber strands 32 are in the apex portions 22A of the male threads 22 and the apex portion 30A of the female threads 30. The fiber strands are thus concentrated adjacent the peripheral surface of the sucker rod, at least in the portions forming the male end 14 and the female end 16. It can be seen that, if desired, additional fiber strands may be positioned in the inner portions of the sucker rod, although such are not shown in the drawings. However, the essence of this invention is not simply the concept of including reinforcing strands in plastic sucker rods but including them in such a way as to substantially increase the tensile strength of the sucker rods by providing strands through the male and female threaded portions of the sucker rod.

Turning now to Figs. 5 to 10, a method of manufacturing the improved sucker rod of this invention will be described. The first step is that of saturating a bundle of fibre strands with thermosetting resin as illustrated in Fig. 5. A vessel 34 holds a quantity of catalyzed liquid thermosetting resin 36. By means of rollers 38 a bundle of reinforcing flexible fiber strands 32 can be pulled through the liquid 38 so that strands are completely saturated with the thermosetting resin.

Fig. 6 shows the bottom portion of a split cavity mold for use in forming a sucker rod according to the invention, the top portion having substantially the same appearance and the portions when joined together providing a mold cavity which defines the exterior surface of a completed sucker rod. The bottom half of the mold 42 is open and the bundle of strands 32 is placed in it. The top half of the mold 44 is then placed on the bottom half of the mold as shown in Fig. 8 while the strands 32 are kept under slight tension. The fibers 38 are flared at the ends, as shown in Fig. 7. Thereafter, a male flaring tool 46 is inserted into the open end of the mold formed by portions 42 and 44. The configuration of the male flaring tool 46 is such as to conform closely to the portion of the mold cavity forming the male threads on the completed sucker rod. The flaring tool 46 serves to spread out the fibers so that they are positioned adjacent the cavity surface. The fibers having been saturated with liquid thermosetting resin retain their position adjacent the cavity peripheral surface and the male flaring tool 46 is retained in this position in the mold until the thermosetting resin has crosslinked and cured to a solid condition. After curing, the male flaring tool is

removed and the cavity left by the tool is either plugged or a casting resin used to fill the void.

In like manner, a female flaring tool 48 is inserted into the open end of the mold to closely conform to the interior female threaded configuration at the box end of the sucker rod. The female flaring tool 48 also accomplishes the purpose of spreading out the fiber strands so that the strands extend within the area which forms the apex of the female threads. Additional plastic is added to the mold, pressure is applied, and circulation of heating fluid through piping 50 into the mold is accomplished as shown in Fig. 4.

After the resin in the mold has cured, the mold portions are separated, and the finished sucker rod is removed. The insert which forms the female threads 30 is removed. Thus the sucker rod is cast with its male and female threads without requiring machining operations to produce the threads. In this manner the reinforcing fibers are left intact so they impart full tensile strength throughout the full length of the rod, including the critical area of the threads.

In order to add aditional strength to the box or female end, the cylindrical portion 24 may be wrapped to provide radial strength.

The reinforcing fibers 32 may be such as fiberglass, metal aramid, carbon fibers, graphite fibers, boron fibers or mixtures of these fibers. The thermosetting resin of which the sucker rods may be formed and the resin in which the fibers are saturated as a step in the manufacture of the sucker rods, may be such as epoxy, polyester, vinylester, and the like. The temperature and pressure at which the resin systems is subjected during curing depends upon the nature of the plastic, and such is well known to those experienced in producing products from thermosetting plastics.

The completed sucker rod has substantial advantages over the known techniques of manufacturing sucker rods and particularly has greatly improved tensile strength in the male and female thread portions and complete corrosion protection from all liquids found in oil well production. Also, it eliminates the problem of electrolysis.

CLAIMS

1. A method of manufacturing a fiber reinforced plastic sucker rod having a threaded portion at each end thereof using a split cavity mold which when closed has a cavity defining the external configuration of the finished sucker rod, comprising positioning a plurality of pre-resin saturated flexible reinforcing fiber strands in one-half of the mold, maintaining the strands in proximity of the mold wall in the areas thereof of the threaded end portions while adding additional resin compound to the mold, closing the mold, curing the plastic material within the mold and separating the mold to remove the formed sucker rod.

2. A method as claimed in claim 1, in which the step of maintaining the strands in proximity of the mold wall includes the step of inserting flaring tools in the ends of the mold to outwardly displace the fiber strands forcing them by pressure of the tools to conform to the configuration of the threaded end portion.

3. A method as claimed in claim 1 or 2 in which the step of curing the plastic material within the mold includes the application of steam for fast heat transfer followed after cure by cooling the mold rapidly with water for rapid removal and handling of said sucker rod.

4. A method as claimed in claim 1, 2 or 3, in which maintaining the strands in proximity of the mold is in tension.

5. A method as claimed in claim 1, 2, 3 or 4 in which the step of curing the plastic material within the mold includes the application of heat and pressure in proper sequence.

6. A method as claimed in any of claims 1 to 5, in which the flexible reinforcing fiber strands are saturated with liquid thermosetting resin, the thus saturated fiber strands being positioned in the cavity of the mold lower portion.

7. A plastic sucker rod comprising an elongated sucker rod formed of plastic material having a plurality of reinforcing fiber strands therein, the sucker rod having a threaded portion at each end thereof, the fiber strands in the threaded portions being continuous and generally in planes of the sucker rod longitudinal axis with all of the fiber strands extending within the thread's configuration and apex portions.

8. A sucker rod as claimed in claim 7, in which a male threaded pin end portion is provided at one end and a female threaded box end portion at the other end, the fiber strands extending within the increased external diameter thread forming portions and the reduced internal diameter female thread forming portions.

9. A method of manufacturing a fiber reinforced plastic sucker rod substantially as herein described with reference to Figs. 5 to 10 of the accompanying drawings.

10. A fiber reinforced plastic sucker rod constructed and arranged substantially as herein described with reference to Figs. 1 to 4 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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